APPENDIX G-1

AIR QUALITY BACKGROUND INFORMATION

BACKGROUND INFORMATION ON AIR QUALITY

Air Pollution Terminology

The discussion of air pollution issues requires an understanding of terms that have a technical meaning. It is especially important to understand the distinction between air pollutant emissions and ambient air quality. Other important terminology includes: primary pollutants, secondary pollutants, and pollutant precursors; aerosols and particulate matter; and ozone precursor emissions terminology.

Emissions and Ambient Air Quality. The term "pollutant emissions" refers to the amount (usually stated as a weight) of one or more specific compounds introduced into the atmosphere by a source or group of sources. In practice, most pollutant emissions data are presented as "emission rates": the amount of pollutants emitted during a specified increment of time or during a specified increment of emission source activity. Typical measurement units for emission rates on a time basis include pounds per hour, pounds per day, or tons per year. Typical measurement units for emission rates on a source activity basis include pounds per thousand gallons of fuel burned, pounds per ton of material processed, and grams per vehicle mile of travel.

The term "ambient air quality" refers to the atmospheric concentration of a specific compound (amount of pollutants in a specified volume of air) actually experienced at a particular geographic location that may be some distance from the source of the relevant pollutant emissions. The ambient air quality levels actually measured at a particular location are determined by the interactions among three groups of factors:

- emissions: the types, amounts, and locations of pollutants emitted into the atmosphere;
- meteorology: the physical processes affecting the distribution, dilution, and removal of these pollutants; and
- chemistry: any chemical reactions that transform pollutant emissions into other chemical substances.

Ambient air quality data are generally reported as a mass per unit volume (e.g., micrograms per cubic meter of air) or as a volume fraction (e.g., parts per million by volume).

Primary Pollutants, Secondary Pollutants, and Pollutant Precursors. Air pollutants are often characterized as being "primary" or "secondary" pollutants. Primary pollutants are those emitted directly into the atmosphere (such as carbon monoxide, sulfur dioxide, lead particulates, and hydrogen sulfide). Secondary pollutants are those (such as ozone, nitrogen dioxide, and sulfate particles) formed through chemical reactions in the atmosphere; these chemical reactions usually involve primary pollutants, normal constituents of the atmosphere, and other secondary pollutants.

Those compounds which react to form secondary pollutants are referred to as reactive pollutants, pollutant precursors, or precursor emission products. Some air pollutants (such as many organic gases and suspended particulate matter) are a combination of primary and secondary pollutants.

The distinction between primary and secondary pollutants is more than a matter of semantics; important air quality management implications are also involved. The ambient concentration of primary pollutants depends on the spatial concentration of the emission sources, the rate of pollutant emissions, and the degree to which the emitted pollutants are dispersed or removed from the atmosphere between the emission source and the location of interest. Air quality problems involving primary pollutants (such as carbon monoxide) often can be traced to a single pollutant source or a concentrated group of sources emitting large quantities of the pollutant. Additionally, the responsible emission source will be relatively close to the location of the air quality problem. The distance between the emission source and the location of a ground-level air quality problem depends largely on the height at which the emissions are released into the atmosphere.

When an air quality problem involves a secondary pollutant (such as ozone), the spatial relationship between emission sources and ambient air quality problems becomes much more complicated. Because secondary pollutants are not emitted directly into the atmosphere, observed ambient concentrations may not show a clear correlation with the spatial distribution of sources emitting the pollutant precursors. The time factor involved in the chemical reactions producing secondary pollutants allows emissions from numerous sources to become dispersed and mixed together. As a result, the observed ambient pollutant concentrations are due as much to the cumulative areawide emissions of precursors as to the spatial concentration of emission sources.

Aerosols and Particulate Matter. Most people would interpret the term "aerosol" as indicating some type of liquid droplet or mist sprayed into the air. Similarly, most people would interpret the term "particulate matter" as implying a solid particle (such as dust or fly ash). In the air pollution field, however, the terms "aerosol" and "particulate matter" are used interchangeably; both terms can refer to either liquid or solid material suspended in the air.

Ozone Precursor Emissions. Ozone, a major component of photochemical smog, is the secondary pollutant of greatest concern in most parts of the country. The pollutant emissions generally categorized as ozone precursors fall into two broad groups of chemicals: nitrogen oxides and organic compounds. Many different terms are used to refer to these groups of ozone precursors. As indicated below, the various terms are seldom used in a rigorous chemical sense.

The terms "nitrogen oxides" and "oxides of nitrogen" are used interchangeably to refer to the combination of nitric oxide (designated by the chemical symbol NO) and nitrogen dioxide (designated by the chemical symbol NO_2). This combination of nitrogen oxides often is designated by the symbol NOx. Although there are five different oxides of nitrogen, the terms "nitrogen oxides", "oxides of nitrogen", and "NOx" generally refer only to the combination of NO and NO_2. NO_2 is itself a secondary pollutant formed primarily from nitric oxide.

Organic compound precursors of ozone are routinely described by a number of variations on three terms: hydrocarbons (HC), organic gases (OG), and organic compounds (OC). These three basic terms are often modified by adjectives such as total, reactive, or volatile. The result is a rather

confusing array of acronyms: HC (hydrocarbons), THC (total hydrocarbons), RHC (reactive hydrocarbons), TOG (total organic gases), ROG (reactive organic gases), TOC (total organic compounds), ROC (reactive organic compounds), and VOC (volatile organic compounds). An additional term, NMHC (nonmethane hydrocarbons), is also used on occasion.

To a chemist, most of these terms differ from each other in some significant way. In the air pollution control field, however, they are used as two groups of interchangeable terms. THC, TOG, and TOC imply a comprehensive grouping of chemicals including some (such as methane and many chlorinated organic compounds) that have no significant role in photochemical reactions in the lower atmosphere. The other terms (HC, RHC, ROG, ROC, VOC, and NMHC) imply a grouping of chemicals limited to those that play a meaningful role in photochemical reactions in the lower atmosphere.

From a purely chemical standpoint, the "hydrocarbon" terminology (HC, THC, RHC, and NMHC) often is inappropriate; many of the compounds of concern are organic compounds, but not hydrocarbons. The "reactive organic gases" (ROG) terminology incorrectly implies that compounds which condense into an aerosol droplet cease to play a role in smog photochemistry. The "volatile organic compound" (VOC) terminology incorrectly implies that emissions occur only through an evaporation process. The phrase "reactive organic compounds" (ROC) usually is the most accurate ozone precursor terminology, but the ROC acronym is not in widespread use. Since there already are too many acronyms for ozone precursors, the ROG acronym is the most reasonable one to use, and will be used in this document.

Air Quality Standards

Air quality management programs have evolved using two distinct management approaches: one approach based on setting and achieving ambient air quality standards, and a parallel approach of setting emission limits for individual sources of air pollutants considered to be hazardous.

The ambient standards approach to air quality management typically entails:

- setting ambient air quality standards for acceptable exposure to selected air pollutants;
- conducting monitoring programs to identify locations exposed to air pollutant concentrations exceeding the standards; and
- developing programs and regulations designed to reduce or eliminate the identified high exposure conditions in a timely manner.

The hazardous air pollutant emission limits approach to air quality management typically entails:

- identifying specific chemical substances that are potentially hazardous to human health, and then
- setting emission limits to regulate the amount of those substances that can be released by individual commercial or industrial facilities or by specific types of equipment.

Ambient Air Quality Standards for Criteria Pollutants. Air quality programs based on ambient air quality standards typically address air pollutants that are produced in large quantities by widespread types of emission sources and which are of public health concern because of their toxic

properties. The U.S. Environmental Protection Agency (EPA) has established ambient air quality standards for several different pollutants, which often are referred to as criteria pollutants (ozone, nitrogen dioxide, carbon monoxide, sulfur dioxide, suspended particulate matter, and lead). Federal ambient air quality standards apply to outdoor locations to which the general public has access. Standards for suspended particulate matter have been set for two size fractions: inhalable particulate matter (PM_{10}), fine particulate matter ($PM_{2.5}$). In the case of some air pollutants, separate standards have been set for different averaging times. Federal ambient air quality standards are based primarily on evidence of acute and chronic health effects.

Some states have adopted ambient air quality standards that are more stringent than the comparable federal standards or address pollutants that are not covered by federal ambient air quality standards. Most state ambient air quality standards are based primarily on health effects data, but can reflect other considerations such as protection of crops, protection of materials, or avoidance of nuisance conditions (such as objectionable odors). Table 1 summarizes federal and state ambient air quality standards applicable in Hawai'i.

Air pollutants covered by federal and state ambient air quality standards can be categorized by the nature of their toxic effects as:

- irritants (such as ozone, particulate matter, nitrogen dioxide, sulfur dioxide, and hydrogen sulfide) that affect the respiratory system, eyes, mucous membranes, or the skin;
- asphyxiants (such as carbon monoxide and nitric oxide) that displace oxygen or interfere with oxygen transfer in the circulatory system, affecting the cardiovascular and central nervous systems;
- necrotic agents (such as ozone, nitrogen dioxide, and sulfur dioxide) that directly cause cell death; or
- systemic poisons (such as lead particles) that affect a range of tissues, organs, and metabolic processes.

Ozone, suspended particulate matter, and carbon monoxide are the air pollutants of greatest concern in most parts of the country. Ozone is a strong oxidizing agent that reacts with a wide range of materials and biological tissues. Ozone is a respiratory irritant that can cause acute and chronic effects on the respiratory system. Recognized effects include reduced pulmonary function, pulmonary inflammation, increased airway reactivity, aggravation of existing respiratory diseases (such as asthma, bronchitis, and emphysema), physical damage to lung tissue, decreased exercise performance, and increased susceptibility to respiratory infections. In addition, ozone is a necrotic agent that causes significant damage to leaf tissues of crops and natural vegetation. Ozone also damages many materials by acting as a chemical oxidizing agent. Because of its chemical activity, indoor ozone levels are usually much lower than outdoor levels.

Suspended particulate matter represents a diverse mixture of solid and liquid material having size, shape, and density characteristics that allow the material to remain suspended in the air for meaningful time periods. The physical and chemical composition of suspended particulate matter is highly variable, resulting in a wide range of public health concerns.

TABLE 1. AMBIENT AIR QUALITY STANDARDS APPLICABLE IN HAWAI'I

POLLUTANT	SYMBOL	AVERAGING TIME	STANDARD AS PARTS PER MILLION BY VOLUME		STANDARD AS MICROGRAMS PER CUBIC METER		VIOLATION CRITERIA	
			HAWAII	NATIONAL	HAWAII	NATIONAL	HAWAII	NATIONAL
Ozone	O_3	8 Hours	0.08	0.08	157	157	If exceeded on more than 1 day per year	If exceeded by the mean of annual 4th highest daily values for a 3-year period
Carbon Monoxide	CO	8 Hours	4.5	9	5,000	10,000	If exceeded on more than 1 day per year	If exceeded on more than 1 day per year
		1 Hour	9	35	10,000	40,000	If exceeded on more than 1 day per year	If exceeded on more than 1 day per year
Inhalable Particulate Matter	PM_{10}	Annual Arithmetic Mean	---	---	50	50	If exceeded	If exceeded as a 3-year single station average
		24 Hours	---	---	150	150	If exceeded on more than 1 day per year	If exceeded by the mean of annual 99th percentile values over 3 years

TABLE 1 (continued). AMBIENT AIR QUALITY STANDARDS APPLICABLE IN HAWAI'I

POLLUTANT	SYMBOL	AVERAGING TIME	STANDARD AS PARTS PER MILLION BY VOLUME		STANDARD AS MICROGRAMS PER CUBIC METER		VIOLATION CRITERIA	
			HAWAII	NATIONAL	HAWAII	NATIONAL	HAWAII	NATIONAL
Fine Particulate Matter	$PM_{2.5}$	Annual Arithmetic Mean	---	---	---	15.0	---	If exceeded as a 3-year spatial average of data from designated stations
		24 Hours	---	---	---	65	---	If exceeded by the mean of annual 98th percentile values over 3 years
Nitrogen Dioxide	NO_2	Annual Average	0.037	0.053	70	100	If exceeded	If exceeded
Sulfur Dioxide	SO_2	Annual Average	0.03	0.03	80	80	If exceeded	If exceeded
		24 Hours	0.14	0.14	365	365	If exceeded on more than 1 day per year	If exceeded on more than 1 day per year
		3 Hours	0.5	0.5	1,300	1,300	If exceeded on more than 1 day per year	If exceeded on more than 1 day per year

TABLE 1 (continued). AMBIENT AIR QUALITY STANDARDS APPLICABLE IN HAWAI'I

POLLUTANT	SYMBOL	AVERAGING TIME	STANDARD AS PARTS PER MILLION BY VOLUME		STANDARD AS MICROGRAMS PER CUBIC METER		VIOLATION CRITERIA	
			HAWAII	NATIONAL	HAWAII	NATIONAL	HAWAII	NATIONAL
Lead Particles (TSP Sampler)	Pb	Calendar Quarter	---	---	1.5	1.5	If exceeded	If exceeded
Hydrogen Sulfide	H_2S	1 Hour	0.025	---	35	---	If exceeded on more than 1 day per year	---

Notes:

All standards except the national PM10 and PM2.5 standards are based on measurements corrected to 25 degrees C and 1 atmosphere pressure.

The national PM10 and PM2.5 standards are based on direct flow volume data without correction to standard temperature and pressure.

Decimal places shown for standards reflect the rounding precision used for evaluating compliance.

Gaseous pollutant concentration equivlencies (parts per million by volume versus micrograms per cubic meter) are nominal values accounting for rounding conventions; exact equivalencies may be different.

Except for the 3-hour sulfur dioxide standard, the national standards shown are the primary (health effects) standards.

The national 3-hour sulfur dioxide standard is a secondary (welfare effects) standard.

The national PM10 standards were adopted in 1987; revised violation criteria were adopted for attainment areas in 1997.

The original violation criteria for the national PM10 standards will remain in effect for PM10 nonattainment areas until EPA takes actions required by Section 172(e) of the Clean Air Act or approves emission control programs for the relevant PM10 state implementation plan.

TABLE 1 (continued). AMBIENT AIR QUALITY STANDARDS APPLICABLE IN HAWAI'I

Notes (continued):

Violation criteria for all standards except the national annual standard for PM2.5 are applied to data from individual monitoring sites.

Violation criteria for the national annual standard for PM2.5 are applied to a spatial average of data from one or more community-oriented monitoring sites representative of exposures at neighborhood or larger spatial scales (40 CFR Part 58).

The "10" in PM10 and the "2.5" in PM2.5 are not particle size limits; these numbers identify the particle size class (aerodynamic equivalent diameters in microns) collected with 50% mass efficiency by certified sampling equipment. The maximum particle size collected by PM10 samplers is about 50 microns aerodynamic equivalent diameter; the maximum particle size collected by PM2.5 samplers is about 6 microns aerodynamic equivalent diameter. (40 CFR Part 53).

Data Sources:

40 CFR Parts 50, 53, and 58.

Hawaii Administrative Rules Chapter 11-59 (August 28, 2001).

Many components of suspended particulate matter are respiratory irritants. Some components (such as crystalline or fibrous minerals) are primarily physical irritants. Other components are chemical irritants (such as sulfates, nitrates, and various organic chemicals). Suspended particulate matter also can contain compounds (such as heavy metals and various organic compounds) that are systemic toxins or necrotic agents. Suspended particulate matter or compounds adsorbed on the surface of particles can also be carcinogenic or mutagenic chemicals.

Public health concerns for suspended particulate matter focus on the particle size ranges likely to reach the lower respiratory tract or the lungs. Inhalable particulate matter (PM_{10}) represents particle size categories that are likely to reach either the lower respiratory tract or the lungs after being inhaled. Fine particulate matter ($PM_{2.5}$) represents particle size categories likely to penetrate to the lungs after being inhaled. The "10" in PM_{10} and the "2.5" in $PM_{2.5}$ are not upper size limits. These numbers refer to the particle size range collected with 50% mass efficiency by certified sampling devices; larger particles are collected with lower efficiencies and smaller particles are collected with higher efficiencies.

In addition to public health impacts, suspended particulate matter causes a variety of material damage and nuisance effects: abrasion; corrosion, pitting, and other chemical reactions on material surfaces; soiling; and transportation hazards due to visibility impairment.

Carbon monoxide is a public health concern because it combines readily with hemoglobin in the blood, and thus reduces the amount of oxygen transported to body tissues. Relatively low concentrations of carbon monoxide can significantly affect the amount of oxygen in the blood stream since carbon monoxide binds to hemoglobin 200-250 times more strongly than oxygen. Both the cardiovascular system and the central nervous system can be affected when 2.5-4.0 percent of the hemoglobin in the blood is bound to carbon monoxide rather than to oxygen. Because of its low chemical reactivity and low solubility, indoor carbon monoxide levels usually are similar to outdoor levels.

Hazardous Air Pollutants. Air quality programs based on regulation of other hazardous substances typically address chemicals used or produced by limited categories of industrial facilities. Programs regulating hazardous air pollutants focus on: substances that alter or damage the genes and chromosomes in cells (mutagens); substances that affect cells in ways that can lead to uncontrolled cancerous cell growth (carcinogens); substances that can cause birth defects or other developmental abnormalities (teratogens); substances with serious acute toxicity effects; and substances that undergo radioactive decay processes, resulting in the release of ionizing radiation. Federal air quality management programs for hazardous air pollutants focus on setting emission limits for particular industrial processes rather than setting ambient exposure standards. Some states have established ambient exposure guidelines for various hazardous air pollutants, and use those guidelines to as part of the permit review process for industrial emission sources.

The State of Hawai'i has adopted ambient concentration guidelines for hazardous air pollutants. Those guidelines are used as part of the permit review process for emission sources that require state or federal air quality permits. The Hawai'i ambient exposure guidelines for hazardous air pollutants (Hawai'i Administrative Rules Title 11 Chapter 60.1, Section 179) include the

following:

- for non-carcinogenic compounds, an 8-hour average concentration equal to 1 percent of the corresponding 8-hour permissible exposure limit (PEL) value adopted by the Occupational Safety and Health Administration (OSHA);
- for non-carcinogenic compounds, an annual average concentration equal to 1/420 (0.238 percent) of the 8-hour PEL value adopted by OSHA;
- for non-carcinogenic compounds for which there is no OSHA-adopted PEL, the Director of Health is authorized to set ambient air concentration standards on a case-by-case basis so as to avoid unreasonable endangerment of public health with an adequate margin of safety; and
- for carcinogenic compounds, any ambient air concentration that produces an individual lifetime excess cancer risk of more than 10 in 1 million assuming continuous exposure for 70 years.

Air Quality Planning Programs

The federal Clean Air Act requires each state to identify areas which have ambient air quality in violation of federal standards. States are required to develop, adopt, and implement a State Implementation Plan (SIP) to achieve, maintain, and enforce federal ambient air quality standards in these nonattainment areas. Deadlines for achieving the federal air quality standards vary according to air pollutant and the severity of existing air quality problems. The SIP must be submitted to and approved by EPA. SIP elements are developed on a pollutant-by-pollutant basis whenever one or more air quality standards are being violated.

The status of areas with respect to federal ambient air quality standards is categorized as nonattainment, attainment (better than national standards), unclassifiable, or attainment/cannot be classified. For most air pollutants, initial federal status designations are made using only two categories (either nonattainment and unclassifiable/attainment, or nonattainment and attainment/cannot be classified). For simplicity and clarity, the federal unclassifiable and attainment/cannot be classified designations will be called unclassified in this document. The unclassified designation includes attainment areas that comply with federal standards as well as areas for which monitoring data are lacking. Unclassified areas are treated as attainment areas for most regulatory purposes. Areas that have been reclassified from nonattainment to attainment of federal air quality standards are automatically considered "maintenance areas", although this designation is seldom noted in status listings. The entire state of Hawai'i is categorized as attainment or unclassified for each of the federal ambient air quality standards.

Existing Air Quality Conditions

The State of Hawai'i currently operates 9 ambient air quality monitoring stations on the Island of O'ahu, 1 station on the Island of Kaua'i, 2 stations on the Island of Maui, and 5 stations on the Island of Hawai'i. All of the monitoring stations are located in coastal regions, with many of the monitoring stations located in or near urbanized areas. None of the monitoring stations are located at or near Army training areas. The monitoring stations on Maui are located to monitor the air

quality impacts of sugar cane burning. The monitoring stations on the Island of Hawai'i have been located primarily to monitor the impacts of emissions from volcanic eruptions and geothermal development. Based on available monitoring data and the locations of recognized emission sources, EPA has concluded that no locations in Hawai'i exceed federal ambient air quality standards. Consequently, the entire state is considered to be in attainment of all federal ambient air quality standards.

Most of the monitoring data collected in recent years shows that ambient air quality levels are well below the values of the relevant state and federal ambient air quality standards. Two factors help maintain good air quality conditions in Hawai'i: the isolated location of the state, and the small size of the islands. The state's isolated location prevents other areas from contributing background pollutant concentrations. The small size of the islands in the state minimizes the time air masses remain over land areas, and hence limits the accumulation and development of high air pollutant concentrations. The small size of the islands combined with relatively persistent trade wind directions also minimize recirculating airflow patterns that contribute to air pollution buildup in continental areas. The isolated location and small size of Hawai'i are particularly important in minimizing ozone concentrations, since climatic factors (warm temperatures and high sunlight intensities) are otherwise favorable for the photochemical reactions that produce ozone. Although overall conditions generally minimize air pollution levels, high intensity emission sources or extended periods of light and variable winds can allow the development of localized air quality problems.

As illustrated in Table 2, only two pollutants (ozone and PM_{10}) have approached or exceeded relevant state or federal standards. Up until September 2001, the state of Hawai'i had a very stringent 1-hour ozone standard of 100 micrograms per cubic meter (0.05 parts per million). This one-hour ozone standard was typically exceeded on several days each year at the Sand Island monitoring station in the Honolulu area. In September 2001 the state 1-hour ozone standard was replaced with an 8-hour average standard numerically equal to the federal 8-hour ozone standard. Available data show that ozone levels in Hawai'i have not approached or exceeded the 8-hour ozone standard.

PM_{10} concentrations at some locations have approached or exceeded the state and federal 24-hour standard of 150 micrograms per cubic meter. Maximum 24-hour PM_{10} concentrations often exceed 100 micrograms per cubic meter at one or both monitoring stations on Maui, and sometimes exceed 100 micrograms per cubic meter at the Pearl City and Kapolei monitoring stations on O'ahu. The high PM_{10} concentrations at monitoring stations on Maui are associated with agricultural burning activities. The high PM_{10} concentrations at Pearl City and Kapolei have been attributed to the use of fireworks during New Year's Day celebrations. Two episodes of 24-hour PM_{10} concentrations over 150 micrograms per cubic meter have been recorded at Pearl City in 2000, with one additional episode in 2001. The two episodes in 2000 represented a violation of the state 24-hour PM_{10} standard, but did not constitute a violation of the federal 24-hour PM_{10} standard.

TABLE 2. MAXIMUM AIR POLLUTANT CONCENTRATIONS ON O'AHU AND HAWAI'I

ISLAND	POLLUTANT	AVERAGING TIME	PEAK CONCENTRATION, MICROGRAMS PER CUBIC METER					HAWAI'I STANDARD	FEDERAL STANDARD
			1997	1998	1999	2000	2001		
O'AHU	OZONE	1 HOUR	**106**	**114**	**110**	98	**104**	100	235
		8 HOUR	nd	nd	nd	nd	nd	157	157
		ANNUAL	37	41	40	32	36	NA	NA
	NO2	ANNUAL	8	8	7	9	8	70	100
	CO	1 HOUR	5,871	6,726	4,788	4,332	5,244	10,000	40,000
		8 HOUR	2,679	2,537	2,337	2,166	2,921	5,000	10,000
		ANNUAL	1,033	960	1,048	905	881	NA	NA
	SO2	3 HOUR	61	99	50	72	61	1,300	1,300
		24 HOUR	20	24	11	20	25	365	365
		ANNUAL	6	4	2	3	4	80	80
	PM10	24 HOUR	45	103	133	**164**	**167**	150	150
		ANNUAL	18	20	18	17	19	50	50
	H2S	1 HOUR	nd	nd	nd	nd	nd	35	NA
	Number of Events Over Standard								
	OZONE	1 HOUR	13	7	8	0	1	100	
	PM10	24 HOUR	0	0	0	2	1	150	
HAWAI'I	OZONE	1 HOUR	nd	nd	nd	nd	nd	100	235
	NO2	ANNUAL	nd	nd	nd	nd	nd	70	100
	CO	1 HOUR	nd	nd	nd	nd	nd	10,000	40,000
	SO2	3 HOUR	nd	nd	652	438	461	1,300	1,300
		24 HOUR	nd	nd	111	94	101	365	365
		ANNUAL	nd	nd	6	6	8	80	80
	PM10	24 HOUR	nd	nd	30	23	20	150	150
		ANNUAL	nd	nd	15	18	12	50	50
	H2S	1 HOUR	nd	nd	nd	13	8	35	NA

Notes:

nd = no data

NA = not applicable; data reported for trend analysis purposes, but no applicable federal or state standards

Numbers in **bold** = values exceeding the most stringent applicable state or federal standard.

The Hawai'i 1-hour ozone standard was replaced in September 2001 by an 8-hour standard numerically identical to the federal 8-hour ozone standard.

Based on conventional power function extrapolations and the relationship between peak 1-hour and annual average ozone levels, peak 8-hour ozone levels are probably about 80 to 85 micrograms per cubic meter.

Data Sources: Hawai'i Department of Health Clean Air Branch 1998, 1999, 2000, 2001, 2002.

Climate and Meteorology Conditions

The most prominent feature of the circulation of air across the tropical Pacific is the persistent trade-wind flow in a general east-to-west direction. The trade winds blow across Hawai'i from the northeast quadrant about 80 to 95 percent of the time from May through September and about 50 to 80 percent of the time from October through April. In addition to the trade winds, wind patterns are influenced by major storm systems and by topographic features that alter or channel prevailing wind directions. Topographic features have additional influences on local wind patterns in coastal areas, with up slope/down slope flow patterns often reinforcing sea breeze/land breeze patterns. Local winds tend to move inland from the coast during mid-morning to early evening periods, then reverse direction and flow off-shore during night and early morning hours. The on-shore sea breeze component tends to be stronger than the off-shore land breeze component. Sea breeze/land breeze patterns are most common on the south and west coasts of the Hawaiian Islands.

The combination of a dominant trade wind pattern and limited seasonal changes in the length of day and night combine to limit seasonal variations in weather conditions in Hawai'i. Weather conditions in Hawai'i show a two season pattern, with a winter season of seven months (October through April) and a summer season of five months (May through September). The summer months generally are warmer and drier than the winter months. Most major storms occur during the winter season. Seasonal variations in temperature conditions are mild at lower elevations, with daytime temperatures commonly between 75 and 90 degrees Fahrenheit (24 to 32 Celsius) and nighttime temperatures between 65 and 75 degrees Fahrenheit (18 to 24 Celsius). Topographic features exert a strong influence on rainfall amounts, and also influence temperature patterns at higher elevations. Rainfall amounts range from less than 20 inches per year (51 centimeters per year) on the southern and western coastal areas to over 300 inches per year (762 centimeters per year) on the windward slopes of the high mountains or near the summits of lower mountains on Kaua'i, O'ahu, and Maui.

KEY ACRONYMS

ACGIH: American Conference of Governmental Industrial Hygienists
CO: carbon monoxide
EPA: U.S. Environmental Protection Agency
NESHAP: national emission standards for hazardous air pollutants
NIOSH: National Institute of Occupational Safety and Health
NO: nitric oxide
NO_2: nitrogen dioxide
NOx: oxides of nitrogen (nitric oxide plus nitrogen dioxide)
NSPS: new source performance standards
NSR: new source review
ODC: ozone depleting chemicals
OSHA: Occupational Health and Safety Administration
PEL: permissible exposure limit (an 8-hour time weighted average concentration value)
PM_{10}: inhalable particulate matter
$PM_{2.5}$: fine particulate matter
PSD: prevention of significant deterioration
REL: recommended exposure limit (a workday-based time weighted average concentration)
ROG: reactive organic gases or reactive organic compounds
SIP: State Implementation Plan
SOx: sulfur oxides
TLV: threshold level value (an 8-hour time weighted average concentration value)
TSP: total suspended particulate matter

GLOSSARY OF AIR QUALITY TERMS

Aerodynamic Equivalent Diameter. A standardized method for characterizing the aerodynamic properties of suspended particles according to their relative settling velocities. The aerodynamic equivalent diameter of a particle is the diameter of a sphere with a 1 gram per cubic centimeter density which would have the same settling velocity as the real particle.

Aerosol. Solid or liquid material having size, shape, and density characteristics that allow the material to remain suspended in the atmosphere for more than a few minutes. A synonym for suspended particulate matter.

Air Basin. A regional area defined for air quality management purposes based on considerations that include the constraints of topographic features on meteorology and pollutant transport patterns, and political jurisdiction boundaries that influence the design and implementation of air quality management programs.

Ambient Air. Outdoor air in locations accessible to the general public.

Ambient Air Quality Standards. A combination of air pollutant concentrations, exposure durations, and exposure frequencies that are established as thresholds above which adverse impacts to public health and welfare may be expected. Ambient air quality standards are set on a national level by the U.S. Environmental Protection Agency. Ambient air quality standards are set on a state level by public health or environmental protection agencies as authorized by state law.

Aromatics. A class of organic compounds with a chemical structure based on a 6-member double-bonded carbon ring; examples include benzene, toluene, xylene, and napthalene.

Attainment Area. An area considered to have air quality as good as or better than the National Ambient Air Quality Standards. An area may be an attainment area for one pollutant and a non-attainment area for others.

Cancer. A class of diseases characterized by uncontrolled growth of somatic cells. Cancers are typically caused by one of three mechanisms: chemically induced mutations or other changes to cellular DNA; radiation induced damage to cellular chromosomes; or viral infections that introduce new DNA into cells.

Carbon Monoxide (CO). A colorless, odorless gas which is toxic because it reduces the oxygen-carrying capacity of the blood.

Carcinogen. A chemical substance or type of radiation that can cause cancer in living organisms.

Chlorofluorcarbons (CFCs). A family of inert, nontoxic, and easily-liquefied chemicals used in refrigeration, air conditioning, packaging, insulation, or as solvents or aerosol propellants. Because CFCs are not destroyed in the lower atmosphere they drift into the upper atmosphere where they can be decomposed by high intensity ultraviolet radiation. The chlorine released when CFCs decompose reacts with and destroys ozone in the stratosphere.

Cutpoint Diameter (D50 diameter). A term used to characterize the collection efficiency of particulate matter sampling devices. The 50 percent mass collection efficiency size (D50 diameter) is commonly used as a simple description of sampling device performance. The D50 cutpoint diameter is not a particle size limit; it is merely the size range (as an aerodynamic equivalent diameter) at which the sampling device collects 50 percent of the ambient particle mass. Size categories of suspended particulate matter are typically designated according to the D50 cutpoint of the relevant sampling equipment.

Criteria Pollutant. An air pollutant for which there is a national ambient air quality standard (carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide, inhalable particulate matter, fine particulate matter, or airborne lead particles).

***De Minimis* Level.** A threshold for determining whether various regulatory requirements apply to a particular action or facility. In an air quality context, *de minimis* thresholds typically are based on emissions, facility size, facility activity levels, or other indicators.

Fugitive Emissions. Emissions that could not reasonably be confined or collected in a stack, vent, or similar device that would allow application of emission control equipment.

Hazardous Air Pollutant (HAP). Air pollutants which have been specifically designated by relevant federal or state authorities as being hazardous to human health. Most HAP compounds are designated due to concerns related to carcinogenic, mutagenic, teratogenic properties; severe acute toxic effects; or ionizing radiation released during radioactive decay processes.

Hydrocarbons. A class of organic compounds composed solely of carbon and hydrogen atoms; often used loosely to include substituted hydrocarbons. Hydrocarbons are a subclass of organic compounds. This term is frequently misused as s synonym for "organic compounds".

Maintenance Area. An area that currently meets federal ambient air quality standards but which was previously designated as a nonattainment area. Federal agency actions occurring in a maintenance area are still subject to Clean Air Act conformity review requirements.

Microgram. One one-millionth of a gram.

Micron. A unit commonly used to describe particle size. One one-millionth of a meter (one micrometer).

Mutagen. A chemical substance or physical agent that causes a permanent change to the genes of a cell.

Nitric Oxide (NO). A colorless toxic gas formed primarily by combustion processes that oxidize atmospheric nitrogen gas or nitrogen compounds found in the fuel. A precursor of ozone, nitrogen dioxide, numerous types of photochemically generated nitrate particles (including PAN), and atmospheric nitrous and nitric acids. Most nitric oxide formed by combustion processes is converted into nitrogen dioxide by subsequent oxidation in the atmosphere over a period that may range from several hours to a few days.

Nitrogen Dioxide (NO_2). A toxic reddish gas formed by oxidation of nitric oxide. Nitrogen dioxide is a strong respiratory and eye irritant. Most nitric oxide formed by combustion processes is converted into nitrogen dioxide by subsequent oxidation in the atmosphere. Nitrogen dioxide is a criteria pollutant in its own right, and is a precursor of ozone, numerous types of photochemically generated nitrate particles (including PAN), and atmospheric nitrous and nitric acids.

Nitrogen Oxides (NO_X). A group term meaning the combination of nitric oxide and nitrogen dioxide; other trace oxides of nitrogen may also be included in instrument-based NO_X measurements. A precursor of ozone, photochemically generated nitrate particles (including PAN), and atmospheric nitrous and nitric acids. See also Reactive Odd-Nitrogen (NO_Y).

Nonattainment Area. An area that does not meet a federal or state ambient air quality standard. Federal agency actions occurring in a federal nonattainment area are subject to Clean Air Act conformity review requirements.

Organic Compounds. Compounds of carbon containing hydrogen and possibly other elements (such as oxygen, sulfur, or nitrogen). Major subgroups of organic compounds include hydrocarbons, alcohols, aldehydes, carboxylic acids, esters, ethers, and ketones. Organic compounds do not include crystalline or amorphous forms of elemental carbon (graphite, diamond, carbon black, etc.), the simple oxides of carbon (carbon monoxide and carbon dioxide), metallic carbides, or metallic carbonates.

Ozone (O_3). A compound consisting of three oxygen atoms. Ozone is a major constituent of photochemical smog that is formed through chemical reactions in the atmosphere involving reactive organic compounds, nitrogen oxides, and ultraviolet light. Ozone is a toxic chemical that damages various types of plant and animal tissues and which causes chemical oxidation damage to various materials. Ozone is a respiratory irritant, and appears to increase susceptibility to respiratory infections. A natural layer of ozone in the upper atmosphere absorbs high energy ultraviolet radiation, reducing the intensity and spectrum of ultraviolet light that reaches the earth's surface.

Particulate Matter. Solid or liquid material having size, shape, and density characteristics that allow the material to remain suspended in the atmosphere for more than a few minutes. Particulate matter can be characterized by chemical characteristics, physical form, or aerodynamic properties. Categories based on aerodynamic properties are commonly described as being size categories, although physical size is not used to define the categories. Many components of suspended particulate matter are respiratory irritants. Some components (such as crystalline or fibrous minerals) are primarily physical irritants. Other components are chemical

irritants (such as sulfates, nitrates, and various organic chemicals). Suspended particulate matter also can contain compounds (such as heavy metals and various organic compounds) that are systemic toxins or necrotic agents. Suspended particulate matter or compounds adsorbed on the surface of particles can also be carcinogenic or mutagenic chemicals.

PM_{10} (inhalable particulate matter [EPA]). A fractional sampling of suspended particulate matter that approximates the extent to which suspended particles with aerodynamic equivalent diameters smaller than 50 microns penetrate to the lower respiratory tract (tracheo-bronchial airways and alveoli in the lungs). In a regulatory context, PM_{10} is any suspended particulate matter collected by a certified sampling device having a 50% collection efficiency for particles with aerodynamic equivalent diameters of 9.5-10.5 microns and an maximum aerodynamic diameter collection limit less than 50 microns. Collection efficiencies are greater than 50% for particles with aerodynamic diameters smaller than 10 microns and less than 50% for particles with aerodynamic diameters larger than 10 microns. NOTE: the ACGIH definition of inhalable particulate mass is based on a D_{50} of 100 microns aerodynamic equivalent diameter.

$PM_{2.5}$ (fine particulate matter [EPA]). A fractional sampling of suspended particulate matter that approximates the extent to which suspended particles with aerodynamic equivalent diameters smaller than 6 microns penetrate into the alveoli in the lungs. In a regulatory context, $PM_{2.5}$ is any suspended particulate matter collected by a certified sampling device having a 50% collection efficiency for particles with aerodynamic equivalent diameters of 2.0-2.5 microns and an maximum aerodynamic diameter collection limit less than 6 microns. Collection efficiencies are greater than 50% for particles with aerodynamic diameters smaller than 2.5 microns and less than 50% for particles with aerodynamic diameters larger than 2.5 microns.

Permissible Exposure Limit (PEL). An occupational air quality standard adopted by the Occupational Safety and Health Administration (OSHA). OSHA PELs are typically adopted as 8-hour time-weighted averages.

Peroxyacetyl Nitrate (PAN). A toxic organic nitrate compound formed by photochemical reactions in the atmosphere. PAN is a strong respiratory and eye irritant, and a strong necrotic agent affecting plant tissues. Also called peroxyacetic nitric anhydride. A number of similar organic nitrate compounds are formed along with PAN during photochemical smog reactions. In relatively remote rural areas PAN and related organic nitrates, together with nitric acid, are often the dominant atmospheric nitrogen compounds.

Precursor. A compound or category of pollutant that undergoes chemical reactions in the atmosphere to produce or catalyze the production of another type of air pollutant.

Reactive Organic Compounds (ROC). The most technically accurate term for the organic precursors of ozone and other photochemically generated pollutants. The more commonly used term is “reactive organic gases (ROG)”.

Reactive Organic Gases (ROG). Organic compounds emitted into the air which have photochemical reaction rates sufficient to be considered precursors of ozone. Organic compounds which are not considered reactive in the lower atmosphere include methane, ethane,

acetone, methyl acetate, carbonic acid, ammonium carbonate, methylene chloride, methyl chloroform, and numerous fully-saturated chloro-flourocarbon compounds. The term "reactive organic compounds" (ROC) would be technically more accurate, since many of the compounds of concern may be present in both gaseous and aerosol states (e.g., as atmospheric aerosols or as liquid films condensed on atmospheric particles in dynamic equilibrium with gas phase vapors). But the acronym ROC is not in common use, and there are far too many acronyms already in use for organic compound emissions.

Recommended Exposure Limit (REL). An occupational air quality guideline recommended by the National Institute of Occupational Safety and Health (NIOSH). NIOSH RELs are typically adopted as time-weighted averages for workdays of up to 10 hours in a 40-hour workweek.

Respirable Particulate Matter (ACGIH definition). Approximately PM_{10} with a 2% collection efficiency at 25 microns aerodynamic equivalent diameter. The collection efficiency curve may differ from EPA PM_{10} certification requirements.

Short-Term Exposure Limit (STEL). An occupational exposure standard adopted by OSHA or an occupational exposure guideline recommended by ACGIH or NIOSH that is typically based on a 15-minute time-weighted average which should not be exceeded at any time during a workday. In some cases, exposure duration periods shorter than or longer than 15 minutes are specified.

State Implementation Plan (SIP). Legally enforceable plans adopted by states and submitted to EPA for approval, which identify the actions and programs to be undertaken by the State and its subdivisions to achieve and maintain national ambient air quality standards in a time frame mandated by the Clean Air Act.

Sulfur Dioxide (SO_2). A pungent, colorless, and toxic oxide of sulfur formed primarily by the combustion of fossil fuels. It is a respiratory irritant, especially for asthmatics. A criteria pollutant in its own right, and a precursor of sulfate particles and atmospheric sulfuric acid.

Sulfur Oxides (SO_X). A group term meaning the combination of sulfur dioxide and sulfur trioxide; treated as a precursor of sulfur dioxide, sulfate particles, and atmospheric sulfuric acid.

Teratogen. A chemical substance or physical agent that causes birth defects through abnormal development or malformation of a fetus.

Thoracic Particulate Matter (ACGIH definition). Approximately PM_4 with a 1% collection efficiency at 10 microns aerodynamic equivalent diameter.

Threshold Limit Value (TLV). An occupational air quality guideline recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). ACGIH TLVs are typically adopted as 8-hour time-weighted averages.

Total Suspended Particulate Matter (TSP). A sampling of suspended particulate matter collected by a standard high volume sampler. The original federal particulate matter standards were based on TSP sampling. The original standards did not define any required collection efficiency parameters for high volume samplers, resulting in significant variability of collection efficiencies for different particle size ranges. TSP samplers are most effective in collecting particles with aerodynamic equivalent diameters smaller than 100 microns, but collection efficiency varies with wind speed and relative sampler orientation to wind direction. The 50 percent cutpoint diameter of TSP samplers typically falls between 15 and 70 microns.

Toxic. Poisonous. Exerting an adverse physiological effect on the normal functioning of an organism's tissues or organs through chemical or biochemical mechanisms following physical contact or absorption.

Toxic Agent. A chemical compound or a mixture of compounds that exerts an adverse physiological effect on a living organism.

Transportation Control Measures (TCMs). Steps taken by a locality to adjust traffic patterns (e.g., bus lanes, right turn on red) or reduce vehicle use (ridesharing, high-occupancy vehicle lanes) to reduce vehicular emissions of air pollutants.

Vehicle Miles Traveled (VMT). The cumulative amount of vehicle travel within a specified geographical area over a given period of time.

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